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(71) Applicants and
(72) Inventors: **KRIEGER, Michael** [US/US]; 34 West Dilido Drive, Miami Beach, Florida 33139 (US). **ELLSWORTH, Kevin** [US/US]; 2224 N. 38th Avenue, Hollywood, Florida 33021 (US). **BABAYI, Robert, S.** [US/US]; 3208 Q Street, N.w., Washington, District Of Columbia 20007 (US). **TSOU, Sander** [US/US]; 6619 Greg Way, Lake Worth, Florida 33467 (US).

(74) Agent: **BABAYI, Robert, S.**; VENABLE, LLC, P.o. Box 34385, Washington, District Of Columbia 20043-9998 (US).

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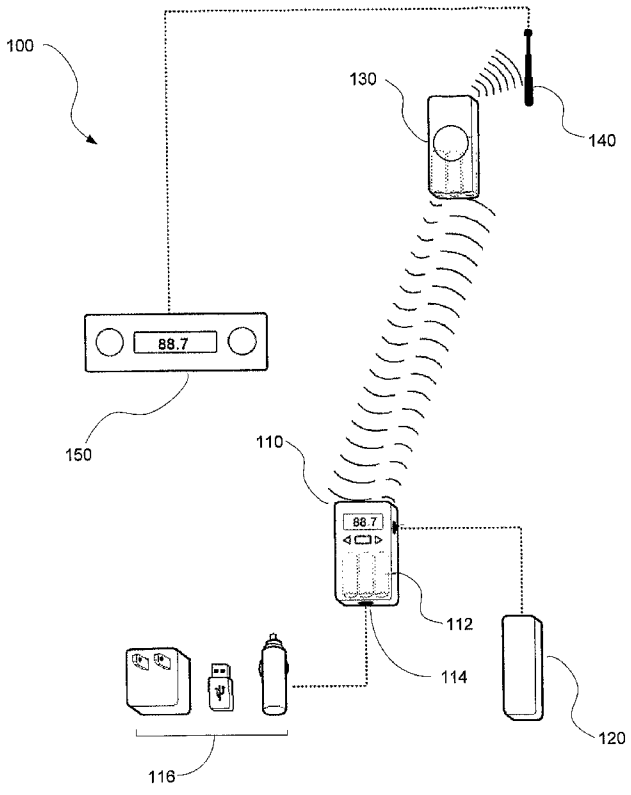
(54) Title: SYSTEM AND METHOD FOR WIRELESS COUPLING OF AUDIO TO A RADIO RECEIVER



(57) Abstract: A system for transmitting audio from an audio source to a radio broadcast receiver operates within a broadcast spectrum. Unlicensed transmissions over the broadcast spectrum, which can cover any one of an FM band, AM band or X-bands, is limited by a transmit power limit. The system comprises a source transmitter that transmits the audio over one or more wireless links. A remote repeater receives the audio over the one or more wireless links and via an unlicensed broadcast transmitter transmits the audio to the broadcast radio receiver at a power level that meets the transmit power limit for unlicensed transmission over the broadcast spectrum. The wireless link operates over a link spectrum that is outside of the broadcast spectrum, such as an ISM band.

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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SYSTEM AND METHOD FOR WIRELESS COUPLING OF AUDIO TO A RADIO RECEIVER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. § 119(e)(1) of provisional application No. 60/742,525, filed December 6, 2005.

FIELD OF THE INVENTION

[0002] The present invention generally relates to a system and method for wireless coupling of audio generated by an audio source to a radio receiver, and more particularly, to transmitting the audio to a radio receiver that operates within a commercial broadcast spectrum, while meeting regulatory limits for unlicensed transmission over such spectrum.

BACKGROUND OF THE INVENTION

[0003] Generally, governmental agencies, such as the Federal Communications Commission (FCC) in the US, regulate transmissions over commercial broadcast spectrums, such as AM and FM bands, by granting licenses to broadcasters. In order to minimize interference, regulatory bodies significantly limit power levels for unlicensed transmissions within the commercial broadcast spectrum. Unlicensed transmitters operating at very low powers have been used to provide coupling between an audio source and a radio receiver, which operates within the commercial broadcast spectrum. For example, low power FM transmitters

have been used for unlicensed transmission of audio from an audio source (e.g., iPod®, MP3 player, CD player, etc.) to an FM radio receiver.

[0004] In one known arrangement, an unlicensed FM transmitter radiates, at very low power levels in compliance with the regulations, a signal that is audio modulated on an FM frequency channel. The radiated signal is received by an FM radio receiver, which is tuned to the FM frequency channel, usually an unused frequency channel within the broadcast spectrum, for example, FM 88.3 MHz, 88.5 MHz or 88.7 MHz. Due to low output transmit power of the unlicensed FM transmitter, however, audio modulated RF signals may not be properly received at the broadcast radio receiver, resulting in degraded audio fidelity.

[0005] In order to overcome problems associated with low transmit power of unlicensed transmissions, Bluetooth® technology has been used for coupling an external audio source to a FM radio receiver. Bluetooth® technology is a specification for wireless personal area networks (PANs), which operates over a license free spectrum of Industrial, Scientific and Medical (ISM) band. The ISM bands are defined by the ITU-R in 5.138 and 5.150 of the Radio Regulations. Individual countries' use of the bands designated in these sections may differ due to variations in national radio regulations. In recent years, the following ISM bands have been used for license-free error-tolerant communications applications such as wireless LANs and Bluetooth:

- 900 MHz band (33.3 cm wavelength)
- 2.4 GHz band (12.5 cm wavelength)

- 5.8 GHz band (5.2 cm wavelength)

[0006] Bluetooth® uses a simple protocol for creation of wireless links in many applications, including remote data exchange, acquisition and control applications. Bluetooth, which operates at the 2.4 GHz range of the ISM band, provides a wireless link to connect and exchange information between devices like personal digital assistants (PDAs), mobile phones, laptops, PCs, printers and digital cameras via a secure, low-cost, globally available short range radio frequency.

[0007] In one application of the Bluetooth® technology, an iPod® Bluetooth® Transmitter/Receiver Kit (iBTRK) offered by Scoche (www.schosche.com) provides for wireless integration of iPod® with external audio equipment, including a car radio. Audio from iPod® is digitized and applied to a Bluetooth® transmitter for transmission over the 2.45 GHz ISM band. A Bluetooth® receiver coupled to an auxiliary audio port of the car stereo recovers that external audio by proper conversion and demodulation of the transmitted Bluetooth® signal.

[0008] However, one of the drawbacks of the iBTRK is that it requires complex installation for coupling the car radio to the Bluetooth® receiver via the auxiliary audio port because current radio receivers are not designed for coupling to a Bluetooh device. Therefore, there exists a need for a simple yet effective system and method for playing high quality audio on a broadcast radio receiver while complying with regulatory transmit power limits for unlicensed transmissions.

SUMMARY OF THE INVENTION

[0009] Briefly, the present invention relates to a system for transmitting audio from an audio source to a radio broadcast receiver that operates within a broadcast spectrum. Unlicensed transmissions over the broadcast spectrum, which can cover any one of an FM band, AM band or X-bands, are limited by a transmit power limit. The system comprises a source transmitter that transmits the audio over one or more wireless links. A remote repeater receives the audio over the one or more wireless links and via an unlicensed broadcast transmitter transmits the audio to the broadcast radio receiver at a power level that meets the transmit power limit for unlicensed transmission over the broadcast spectrum. The wireless link operates over a link spectrum that is outside of the broadcast spectrum, such as an ISM band.

[0010] According to some of the more detailed features of the invention, the unlicensed broadcast transmitter comprises at least one of an FM, AM, or X-band transmitter. The source transmitter and remote repeater, which can be configured as Bluetooth® devices use the one or more wireless links for exchanging data, including control, user interface, media or sensory data. The control data comprises any data used for controlling a function over the one or more wireless links, such as selecting a frequency channel for the unlicensed transmitter. The user interface data comprises any data from a user, for example data relating to setting a channel for the unlicensed transmitter. Media data comprises any one of text, audio, video or image data and sensory data comprises any one of temperature, voltage, speed, distance, position or other sensed parameter data.

[0011] According to other more detailed features of the invention, the audio source is linked with the source transmitter via at least one of a wire or wireless link, such as a satellite, IEEE 802.11x, UWB, WiFi or Bluetooth® link. The audio source can be an internal audio source or an external audio source. In an exemplary embodiment, the internal audio source comprises a satellite radio receiver.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 shows a diagram of a system comprising a source transmitter and a remote repeater, which operate according to the present invention.

[0013] FIG. 2 shows an exemplary block diagram of one embodiment of the source transmitter of the system of FIG. 1.

[0014] FIG. 3 shows an exemplary block diagram of another embodiment of the source transmitter of the system of FIG. 1.

[0015] FIG. 4 shows an exemplary block diagram of the remote repeater of the system of FIG. 1.

[0016] FIG. 5 shows an exemplary block diagram of a Personal Area Network (PAN) comprising the source transmitter and remote repeater of FIGs. 2 and 3..

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] One factor influencing reception quality at a radio receiver is its distance from a transmitter: the closer the transmitter to the radio receiver the better the reception quality. In order to improve reception quality, conventional radio repeaters have been used to extend the range of transmitters and to expand communication coverage in a wide variety of communication applications, including land mobile, cellular, and paging applications. Generally, a radio repeater includes one or more receivers for receiving transmitted signals from one or more correspondingly tuned distant transmitters. The repeater applies the received signals to one or more transmitters for retransmission, thereby increasing communication coverage for portable, mobile, or base station radios that would otherwise not able to communicate with each other.

[0018] The present invention uses a range extending wireless remote repeater that allows for close positioning of a low power unlicensed broadcast transmitter, e.g., an AM, FM, X-band transmitter, relative to a broadcast receiver antenna to improve reception quality, while meeting regulatory requirements for unlicensed transmission over the spectrum. The range extending wireless links having associated link spectrums are used to exchange media content, for example, audio, video, or image content, as well as control or sensory data in a wide variety of applications.

[0019] FIG. 1 shows an exemplary embodiment of a system 100 for low power transmission of audio over a broadcast spectrum, e.g., an AM, FM, X-band. The exemplary embodiment is described in terms of application for transmissions within the specified/regulated

power limits for unlicensed transmissions over the broadcast spectrum of audio generated by an audio source to a broadcast radio receiver, for example, in a vehicle. The system 100 of the present invention includes a source transmitter device 110 for transmitting the audio that is generated by an audio source 120 to a remote repeater 130 over one or more wireless links. At the remote repeater 130, the audio is retransmitted over the broadcast spectrum. The source transmitter 110 and/or remote repeater 130 can be powered in a variety of ways, including by one or more chargeable or non-rechargeable batteries 112 or a power adapter or solar cells. The batteries 112 can be recharged through the recharge port 114 by recharge devices 116, such as a suitable adapter, such a USB, AC, or a cigarette lighter adapter or solar cells that couples a vehicular battery to the source transmitter 110 and/or remote repeater 130. In one embodiment, the remote repeater 130 can be electrically connected to a vehicular batter power directly.

[0020] The audio source 120 can be an internal or external audio source relative to the source transmitter 110. In an exemplary embodiment, an external audio source can comprise any known audio generator, such as an MP3 player, CD player, iPod®, which can be coupled to the source transmitter via a wired or a wireless link, such as an infrared, Ultrawideband (UWB), WiFi or Bluetooth® link. An exemplary audio source internal to the source transmitter can be audio generated by a satellite radio receiver, which outputs audio programs broadcast by a satellite radio service provider, such as Sirius Satellite Radio® (Sirius) or XM Satellite Radio® (XM). Of course, the audio can be generated internally in the source transmitter by any other suitable audio generator, such as an internal MP3 audio source, etc.

[0021] According to one aspect of the invention, wireless links operating outside of the broadcast spectrum are used for exchange of data between the source transmitter 110 and remote repeater 130, which can be positioned at fixed or non-fixed points relative to each other. The data exchanged between the source transmitter 110 and remote repeater 130 can comprise any suitable format, including but not limited to formats representing text, audio, video, image, media, control or sensory signals. Control signals comprise any signal generated at the source transmitter 110 or remote repeater 130 and communicated over a wireless link to perform or control a function. For example, a control signal generated based on user input at the source transmitter 110 can be communicated over the wireless link for setting a transmit frequency over the broadcast spectrum at the remote repeater 130. Examples of sensory signals comprise temperature, voltage, speed, distance, position, etc.

[0022] In the preferred embodiment, the one or more wireless links use a link spectrum that is outside of the broadcast spectrum to avoid interference. In one exemplary embodiment, the wireless link uses a link spectrum designated for unlicensed use, such as an ISM band, which is outside of the broadcast band.

[0023] As stated above, the remote repeater 130 recovers the audio received over the wireless link and retransmits it over the broadcast spectrum. The remote repeater 130 transmits the audio at a power level that meets the regulatory specification for unlicensed transmission. In this way, the remote repeater 130 extends the range for transmitting the audio to the broadcast radio receiver, which allows for positioning of an unlicensed broadcast transmitter at close proximity to the antenna 140 of the broadcast radio receiver 150, thereby improving reception

quality even at the low transmit power levels specified for unlicensed transmissions over the broadcast spectrum. For example, in a vehicular application, the present invention allows the remote repeater 130, which includes the unlicensed broadcast transmitter, to be positioned at an appropriate location inside or on the exterior of an automobile at close proximity to the car radio antenna. At the same time, the wireless links of the remote repeater 130 can be used for exchange of various types of data, such as control or sensory information as well as any suitable media, e.g., audio, video, image data. Control data can be exchanged with the remote repeater 130 for setting a controlled parameter, such as the transmit frequency of the unlicensed broadcast transmitter to a selected frequency channel within the broadcast band.

[0024] The source transmitter 110 includes suitable user interfaces in terms of switches, buttons, displays, etc. to allow a user to generate a suitable control signal, for example, to set the unlicensed transmitter frequency channel. In addition, sensory data can be exchanged between the source transmitter and the remote repeater for informing the user of a sensed parameter, such as temperature or battery power status at the remote repeater, among others. Other examples of sensory parameters that can be exchanged over the wireless links include distance from a barrier or an object as provided by a radar or visual representation or image of the barrier or object as captured by a camera, video image, etc.

[0025] In the exemplary embodiment, Bluetooth® technology is used for implementing the one or more wireless links over which data is exchanged according to the present invention. It should be noted that in addition to Bluetooth®, the source transmitter 110 and remote repeater 130 can be wirelessly linked with each other using any desired

communication protocol, such or those set forth under IEEE 802.11x, including UWB versions thereof.

[0026] The Bluetooth® implementation of the invention complies with Bluetooth® Core Specification Version 2.0 + Enhanced Data Rate (EDR) as promulgated by Bluetooth® Special Interest Group (SIG), which is hereby incorporated by reference. As is well known, Bluetooth® wireless links comply with a radio standard primarily designed for low power consumption, with a short range. Most common classes of Bluetooth® allow for transmission distance of 10 metres (32 ft). In order to avoid interfering with other protocols which use the 2.4 GHz ISM band, the Bluetooth® protocol divides the band into 79 channels (each 1 MHz wide) and changes channels up to 1600 times per second reaching data speeds of up to 2 to 3 Mbit/s, depending on the implementation. As a result multiple Bluetooth® devices can communicate with each other simultaneously when they come within each other's range. Bluetooth® links are created automatically when the devices come within range. Bluetooth® applications can be built and developed using well known tools, such as those offered by LabVIEW.

[0027] The source transmitter 110 and remote repeater 130 are configured to be paired Bluetooth® devices, as set forth in the Bluetooth® specification, which communicate wirelessly when in range. The pairing comprises creation and exchange of a link key between two devices. The devices use the link key for authentication when exchanging information. Bluetooth® devices can communicate with each other as "masters" or "slaves." A Bluetooth® device playing the role of the "master" can communicate with up to 7 devices

playing the role of the "slave". This network of "group of up to 8 devices" (1 master + 7 slaves) is called piconet. Therefore, the present invention can support multiple Bluetooth® devices which form corresponding wireless links and piconots, depending on the application. For example, multiple sensing devices with corresponding Bluetooth® links can be conncted to the remote repeater 130 to support a particular application or service. Also as appropriate, the source transmitter 110 can be linked with other Bluetooth® devices, inlcuding computers or other devices that generate media (e.g., text, audio, video, image, etc.) or conrol (e.g., user interface) as well as sensory signals.

[0028] At any given time, data can be transferred between the master and one slave; but the master switches rapidly from slave to slave in a round-robin fashion. Either device may switch the master/slave role at any time. Each source transmitter and remote repeater has a unique address or "Bluetooth® name" used when scanning for devices and in lists of paired devices. Each device transmits the following sets of information on demand: Device Name, Device Class, List of services, and other technical information, such as device features, manufacturer, clock offset, etc. Any device may perform an "inquiry" to find other devices to which to connect, and any device can be configured to respond to such inquiries. Every device also has a class identifier, which is transmitted when other devices perform an inquiry. The devices also transmit a list of services if requested by another device; this also includes extra information such as the name of the service and what channel it is on. Consequently, multiple devices can be configured and linked to extend the range for close positioning of the remote repeater to an external broadcast radio receiver. Also such devices can be used for

providing wireless links, while avoiding interference issues within the ISM and broadcast spectrum.

[0029] FIG. 2 shows an exemplary block diagram of the source transmitter 110. As stated above, the system of the present invention allows for audio or other media generated by an internal audio or media source 202 or an external audio or media source 204, such as iPod, MP3 or CD player or a satellite radio receiver, to be played on a broadcast radio receiver tuned to operate within a broadcast spectrum or frequency band, including, but not limited to AM, FM, satellite X-band, etc. The broadcast spectrum can comprise any commercial spectrum designated for broadcasting signals or information. The source transmitter 110 includes an audio processor 210 that processes the generated audio, including analog to digital conversion, and formats bits of data for further processing by a Universal Asynchronous Receiver-Transmitter (UART) 212. The UART 212 comprises an integrated circuit that translates between parallel bits of data and serial bits and vice versa. The source transmitter 110 uses the UART for serial communication of audio information over a Bluetooth® serial port. The source transmitter 110 also includes a properly packaged Bluetooth® system-on-chip (SoC) 214. The SoC combines a 2.4GHz transceiver, GFSK/DQPSK/8DPSK modem with complete baseband function to provide an RF front end, link controller and audio functionality, among others. The Bluetooth® SoC 214 also includes a CPU core within the SoC that supports Bluetooth's Enhanced Data Rate (EDR) capabilities at data transfer rates of 2 to 3Mbps and protocol stack software in ROM as well as embedded baseband functionality, which supports all mandatory and optional features of the Bluetooth® specification. The

source transmitter 110 also includes other components 216 external to the SoC, such as capacitors, inductors, and filters.

[0030] A source transmitter controller 220 controls and manages the overall operation of the device including user interface 222 and the execution of software stored in FLASH 224 and RAM 226 memories. Examples of executed software includes audio processing software 232, link management and control software 234, and any other application of user interface software 236. For example, a user can input control parameters into the source transmitter 110 through the user interface 222, which can be configured as keys, buttons, switches, touch sensitive surfaces, or any combinations thereof, etc. In one embodiment, the user interface 222 can be implemented via voice commands. These controller input interfaces can include appropriate indicia in the form of alphanumeric characters, icons, symbols, etc. A graphical user interface on the source transmitter 110 can also be used to provide for user interface 222. In one example, user control information, such as a selected frequency for unlicensed transmitter of the remote repeater 130, can be entered. The control information is modulated on the wireless links for transmission to the remote repeater.

[0031] FIG. 3 shows another exemplary embodiment of the source transmitter 110 configured as a Bluetooth® device where the audio source comprises an internal Satellite radio receiver (Rx). The source transmitter 110 includes a suitably designed Satellite Rx/Bluetooth® chipset comprising a Satellite Rx RF IC 310 and a Satellite RX Application Specific IC (ASIC) 320, as well as RF filtering, external memories, reference frequencies, satellite and Bluetooth® antennas, along with all necessary software required for a complete

solution. The Satellite Rx RF IC 310 can be coupled to an internal or external Satellite antenna, as appropriate, via proper Surface Acoustic Wave (SAW) filtering and amplification over a satellite link. The Satellite Rx RF IC recovers audio broadcast by a satellite service provider, such as Sirius® or XM®, over the satellite link. Similar to the arrangement of FIG. 2, the recovered audio is applied to UART 212 for transmission of the audio over a Bluetooth® link. The source transmitter of FIG. 3 also includes the Bluetooth® system-on-chip (SoC) 214, as described in connection with FIG. 2, for RF front end, baseband, link controller, and audio functionality and implementation of all mandatory and optional features of the Bluetooth® specification.

[0032] FIG. 4 shows an exemplary block diagram of a remote repeater 130, which is configured as a Bluetooth® device. The remote repeater 130 comprises a receiver 410 that receives the transmitted audio from the source transmitter 110 over the wireless links. In this example, the receiver 410 at the remote repeater 130 is implemented within a Bluetooth® SoC 420, which recovers the audio via suitable recovery or demodulation techniques. The recovered audio is then applied to a UART 422 for application to a digital to analog converter 424 providing an analog representation of the recovered audio. An unlicensed broadcast transmitter 426 within the remote repeater 130, which in exemplary embodiments can comprise any one of an FM or AM or X-band transmitter, appropriately modulates and transmits the recovered audio at the remote repeater 130 to a broadcast radio receiver 150. The unlicensed broadcast transmitter 426 transmits the audio over a designated broadcast spectrum channel at a power level that meets the regulatory transmission specification for unlicensed use of the broadcast spectrum. In this way, the remote repeater 130 extends the range for positioning the unlicensed

broadcast transmitter 426 in close proximity to the broadcast radio receiver 150 to improve reception quality and audio fidelity, while meeting the unlicensed low power transmission requirements. A remote repeater controller 430 controls the overall operation of the remote repeater 130 including a user interface 432 and the execution of software stored in FLASH 434 and RAM 436 memories. Examples of executed software include audio processing software 440, link management and control software 442, and any other application of user interface software 444.

[0033] Another function of the remote repeater controller 430 is recovery and decoding of control information transmitted over the one or more wireless links. For example, control information relating to a selected frequency channel for transmission of audio via the unlicensed broadcast transmitter 426 can be processed and applied to a frequency synthesizer to set a selected frequency. Another function control feature of the invention relates to the remote repeater's power saving operation. Under this arrangement, the source transmitter 110 can send control commands to turn off the power at the remote unit, putting it into a sleep mode to conserve battery power. The remote repeater 130 turns the Blue Tooth receiver on momentarily and with all other circuit off every 10 - 15 seconds to look for new control commands from the source transmitter 110. When a control command is received from the source transmitter 110, the remote repeater 130 wakes up and turns on all circuit in a full operation mode. This feature is embedded in the remote repeater 130 software.

[0034] Still another function of the remote repeater controller 430 is performing sensory functions and communicating sensed parameters over a wireless link. The remote repeater is responsive to the sensed parameters for such transmission. The sensed parameters 452 can be obtained via a sensor 450 that is internal to the remote repeater 130 or communicated to it via a remote sensor 460 over a wired or wireless link. The communicated sensed parameters 452 over the wireless link, e.g., temperature or battery voltage can be displayed to a user. In one embodiment, the battery voltage at the remote repeater 130 or the source transmitter 110 can be sensed and communicated over a wireless link to displayed to the to the user via a display unit on the source transmitter or remote repeater, or both.

[0035] FIG. 5 shows a diagram of a network 500 created to implement the present invention. The network 500 comprises a PAN of interconnected Bluetooth® devices. The PAN may comprise source transmitters 110 of FIG. 2 and 3 and the remote repeater 130 of FIG. 4 and other Bluetooth® devices exchanging data, control and/or sensory information. Also shown are wired external audio sources 510 and wireless external audio sources 512, which are linked with the source transmitter 110 via a wire or a wireless link, e.g., a Bluetooth, UWB or WiFi links. Internal, external, as well as wired or wireless sensors can provide sensory information to the remote repeater 130 closely positioned to a broadcast radio receiver for playing the audio generated by the audio source, according to the present invention.

[0036] While the invention has been described with references to its preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teaching of the invention without departing from its essential teachings.

CLAIMS

We claim:

1. A system for transmitting audio from an audio source to a radio broadcast receiver that operates within a broadcast spectrum, wherein unlicensed transmission over the broadcast spectrum is limited by a transmit power limit, said system comprising:

a source transmitter configured to transmit the audio over one or more wireless links; and

a remote repeater configured to receive the audio over the one or more wireless links, the remote repeater comprising an unlicensed broadcast transmitter that transmits the audio to the broadcast radio receiver at a power level that meets the transmit power limit for unlicensed transmission over the broadcast spectrum.

2. The system of claim 1, wherein the one or more wireless links operate over a link spectrum that is outside of the broadcast spectrum.

3. The system of claim 2, wherein the link spectrum comprises an ISM band.

4. The system of claim 1, wherein the unlicensed broadcast transmitter comprises at least one of an FM, AM or X-band transmitter.

5. The system of claim 1, wherein the source transmitter and remote repeater are configured as Bluetooth® devices.

6. The system of claim 1, wherein the broadcast spectrum comprises an FM band, AM band or X-band.

7. The system of claim 1, wherein the source transmitter and remote repeater are configured to exchange data over the one or more wireless links.

8. The system of claim 7, where said data comprises at least one of sense, control, user interface or media data.

9. The system of claim 8, wherein said control data comprises data for controlling a function over the one or more wireless links.

10. The system of claim 9, wherein said function comprises at least one of selection of a frequency channel for the unlicensed transmitter or controlling operational mode of the remote repeater.

11. The system of claim 8, wherein said user interface data comprises at least one of data for setting a channel for the unlicensed transmitter or data related to a voice command.

12. The system of claim 8, wherein said media data comprises at least one of text, audio, video or image data.

13. The system of claim 8, wherein said sensory data comprises at least one of a temperature, voltage, speed, distance, position, video, or image data.

14. The system of claim 1, wherein at least one if the one or more wireless links comprises at least one of a satellite, IEEE 802.11x, UWB, WiFi or Bluetooth® link.

15. The system of claim 1, wherein the audio source is linked with the source transmitter via at least one of a wire or wireless link.

16. The system of claim 1, wherein the audio source comprises at least an internal audio source or an external audio source.

17. The system of claim 16, wherein said internal audio source comprises a satellite radio receiver.

18. The system of claim 16, wherein said internal audio source comprises an MP3 player.

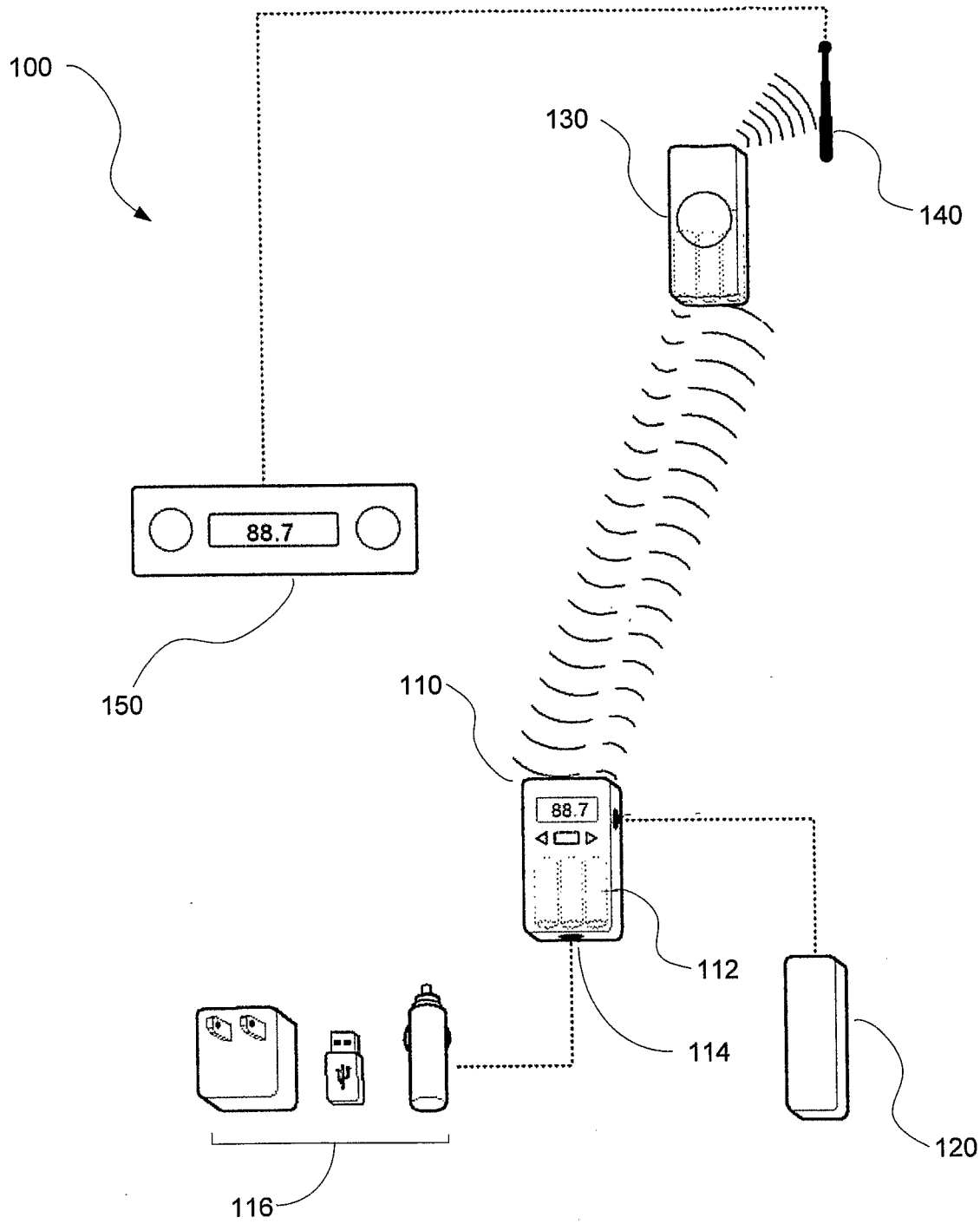
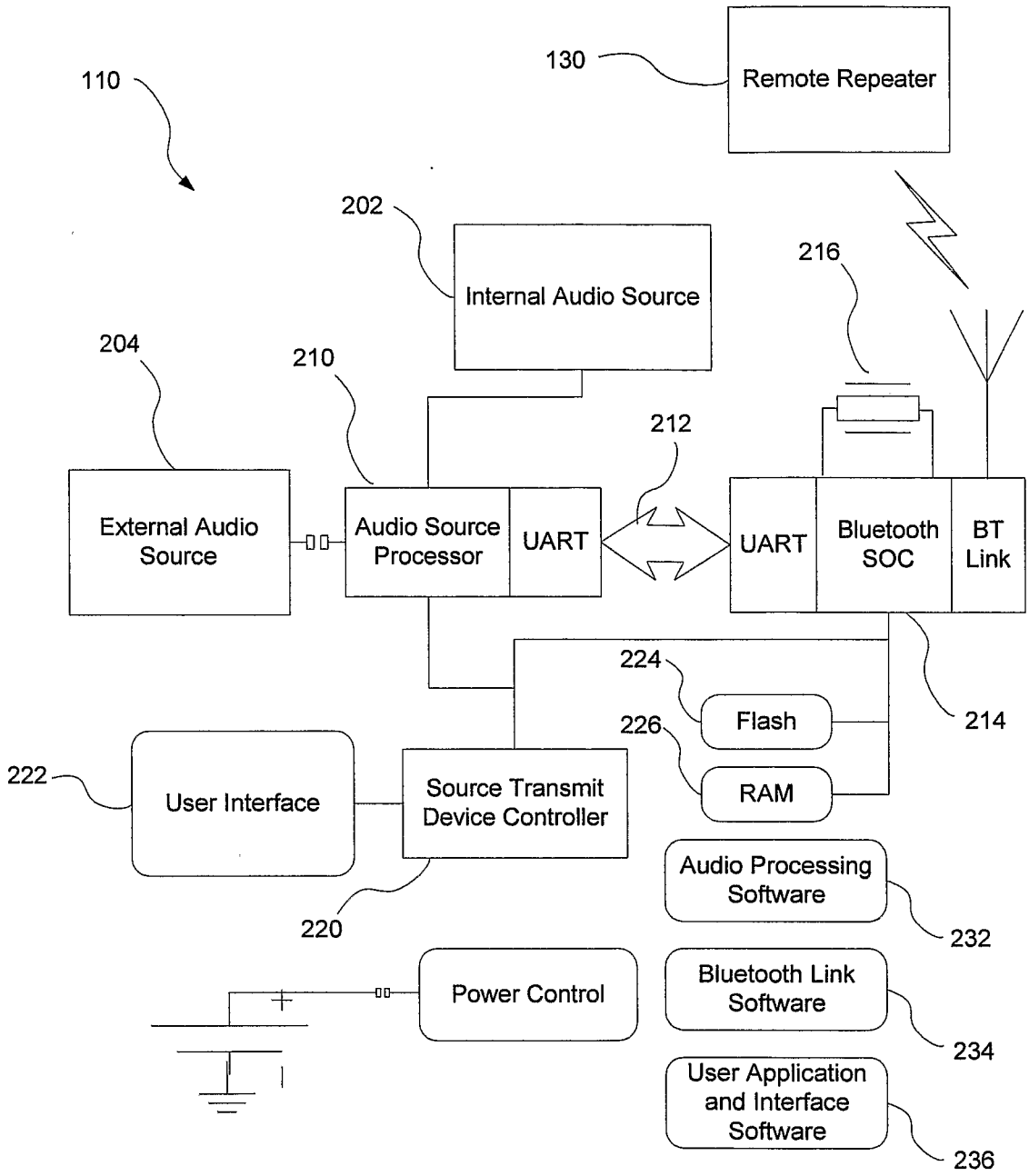


FIG. 1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130
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202
Internal Audio Source
216
204
210
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External Audio Source
Audio Source Processor
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UART
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BT Link
224
214
Flash
226
RAM
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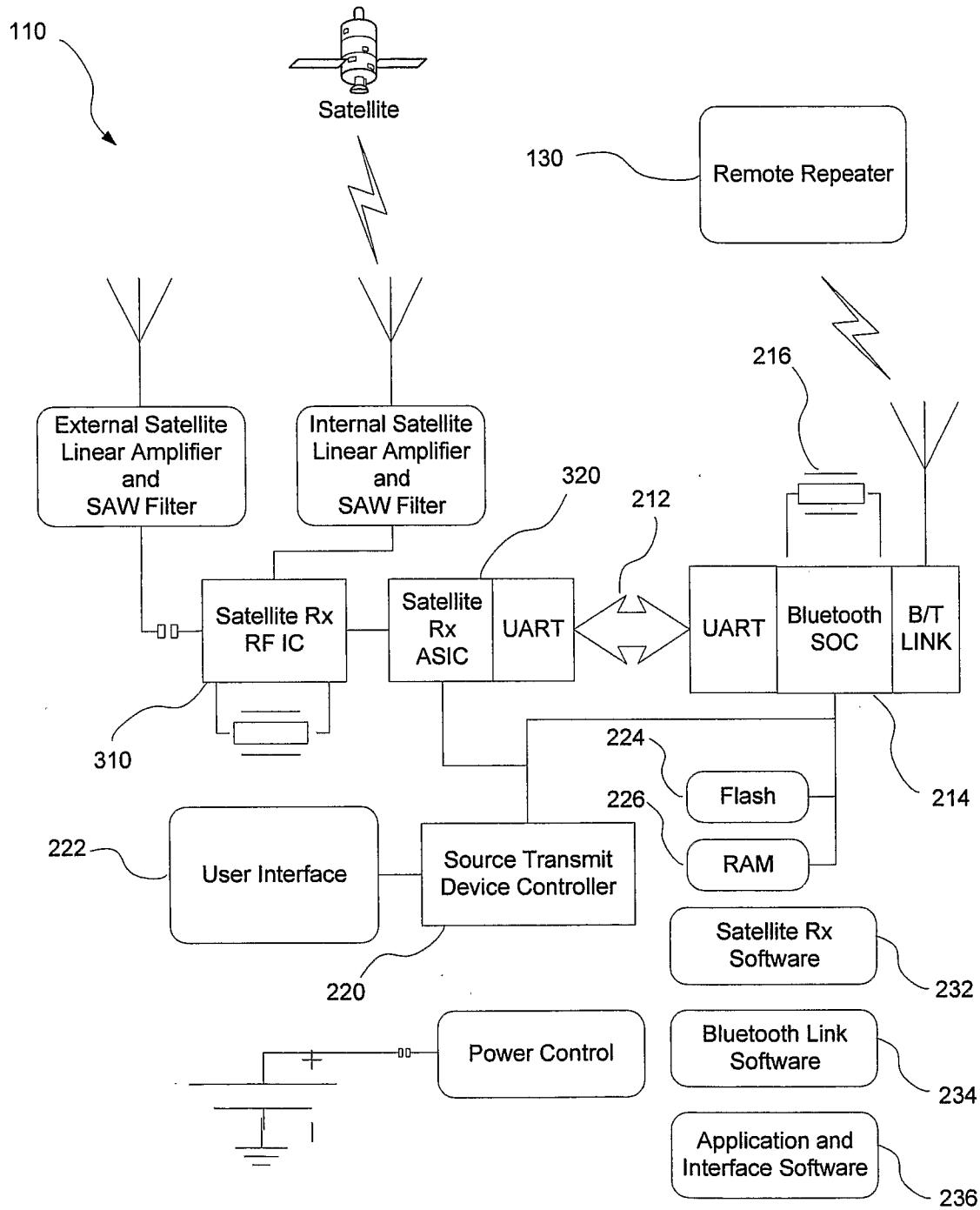
User Interface
Source Transmit Device Controller
Audio Processing Software
232
220
Power Control
Bluetooth Link Software
234
User Application and Interface Software
236

FIG. 2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Remote Repeater
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Internal Satellite Linear Amplifier and SAW Filter
320
212
Satellite Rx RF IC
Satellite Rx ASIC
UART
UART
Bluetooth SOC
B/T LINK
310
224
Flash
214
226
RAM
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Satellite Rx Software
232
220
Power Control
Bluetooth Link Software
234
Application and Interface Software
236

FIG. 3

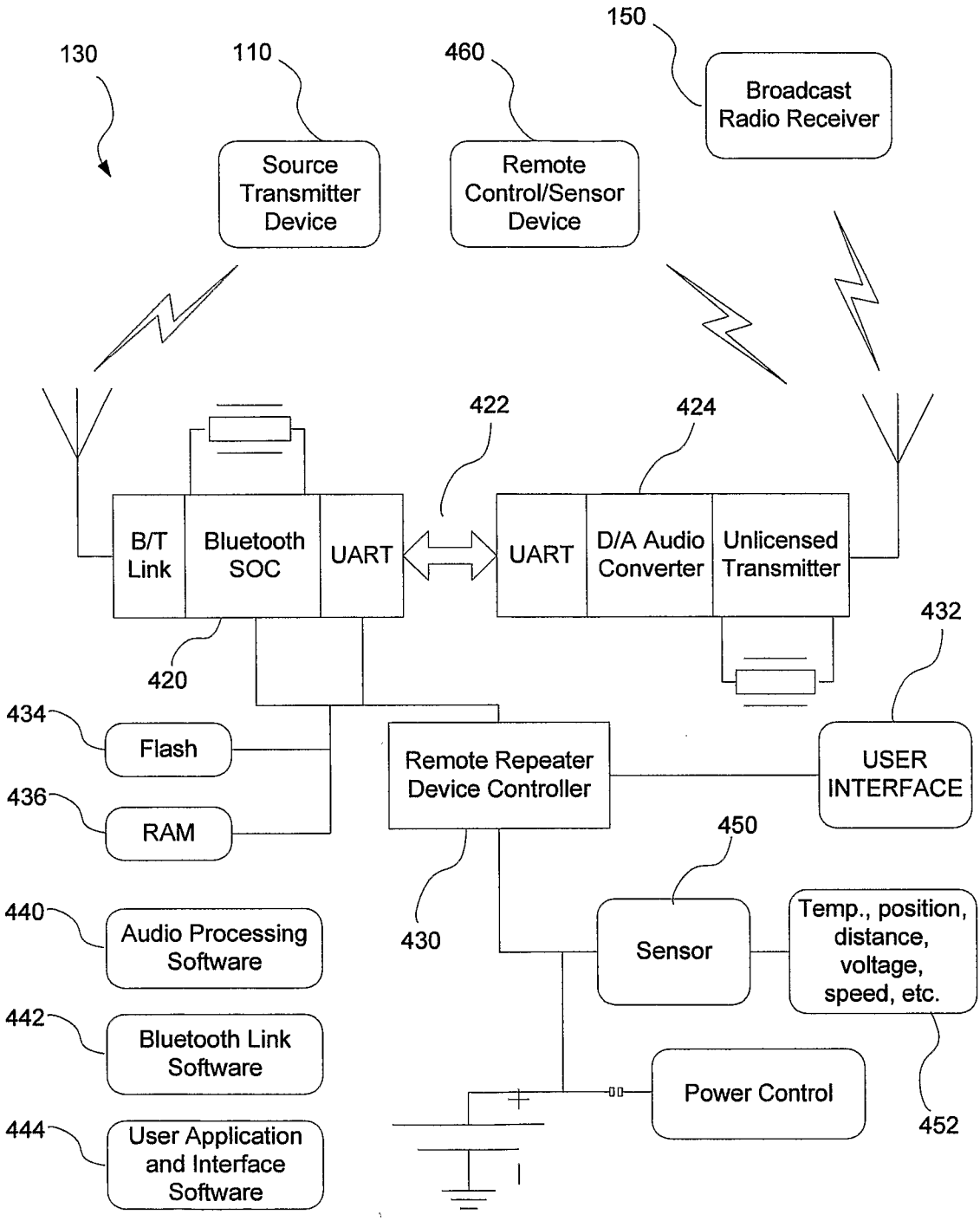
130
110
460
150
Source Transmitter Device
Remote Control/Sensor Device
Broadcast Radio Receiver
422
424
B/T Link
Bluetooth SOC
UART
UART
D/A Audio Converter
Unlicensed Transmitter
420
432
434
Flash
436
RAM
Remote Repeater Device Controller
USER INTERFACE
450
440
Audio Processing Software
430
Sensor
Temp., position, distance, voltage, speed, etc.
442
Bluetooth Link Software
Power Control
444
User Application and Interface Software
452

FIG. 4

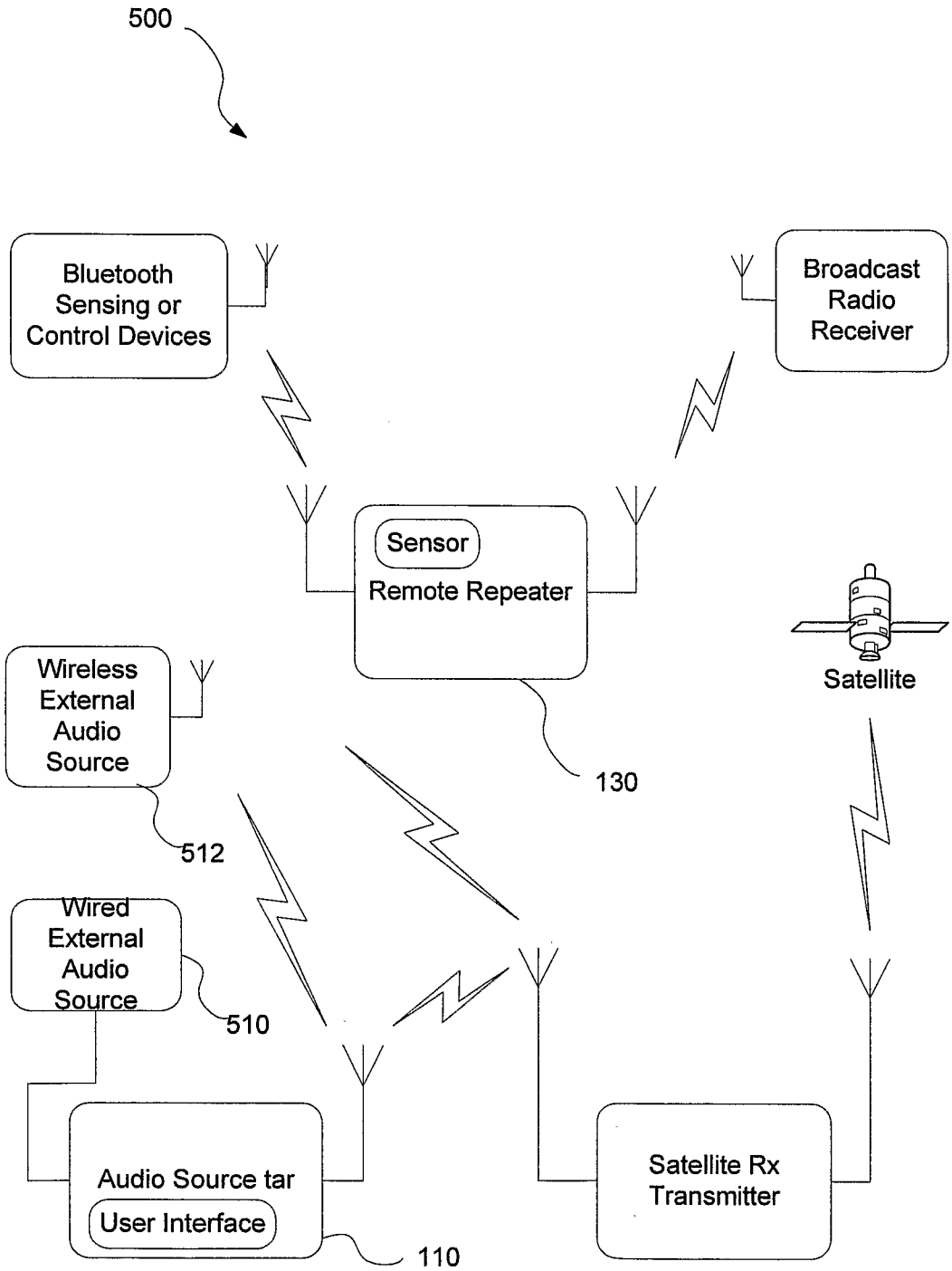
500
Bluetooth Sensing or Control Devices
Broadcast Radio Receiver
Sensor
Remote Repeater
130
Satellite
Wireless External Audio Source
512
Wired External Audio Source
510
Audio Source tar
User Interface
110
Satellite Rx Transmitter

FIG. 5